

WAR FOOD ADMINISTRATION
Agricultural Adjustment Agency

Reserve

SOIL FERTILITY IN ITS BROADER IMPLICATIONS

Lecture delivered before personnel of War Food Administration at Washington, D. C., on June 9, 1944, by Wm. A. Albrecht, Soils Department, College of Agriculture, University of Missouri

Food is fabricated soil fertility. It is food that must win the war and write the peace. Consequently, the questions as to who will win the war and how indelible the peace will be written will be answered by the reserves of soil fertility and the efficiency with which they can be mobilized for both the present and the post-conflict eras.

National consciousness has recently taken consideration of the great losses by erosion from the body of the surface soil. We have also come to give more than passive attention to malnutrition on a national scale. Not yet, however, have we recognized soil fertility as the food-producing forces within the soil that reveal national and international patterns of weakness or strength. Soil fertility, in the last analysis, must not only be mobilized to win the war, but must also be preserved as the standing army opposing starvation for the maintenance of peace.

What is soil fertility? In simplest words, it is some dozen chemical elements in mineral and rock combinations in the earth's crust that are being slowly broken out of these and hustled off to the sea. Enjoying a temporary rest stop enroute, they are a part of the soil and serve their essential roles in nourishing all the different life forms. They are the soil's contribution--from a large mass of nonessentials--to the germinating seeds that empowers the growing plants to use sunshine energy in the synthesis of atmospheric elements and rainfall into the many crops for our support. The atmospheric and rainfall elements are carbon, hydrogen, oxygen, and nitrogen, so common everywhere.

It is soil fertility that constitutes the five per cent that is plant ash. It is the handful of dust that makes up the corresponding percentage in the human body. Yet it is the controlling force that determines whether Nature in her fabricating activities shall construct merely the woody framework with leaf surfaces catching sunshine and with root surfaces absorbing little more than water, or whether inside of that woody shell there shall be synthesized the innumerable life-sustaining compounds.

Soil fertility determines whether plants are foods of only fuel and fattening values, or of body service in growth and reproduction. Because the soil comes in for only a small percentage of our bodies, we are not generally aware of the fact that this five per cent can predetermine the fabrication of the other ninety-five per cent into something more than mere fuel.

HISTORY RECORDS CHANGING POLITICS RATHER THAN DECLINING SOIL FERTILITY

Realization is now dawning that a global war is premised on a global struggle for soil fertility as food. Historic events in connection with the war have been too readily interpreted in terms of armics and politics, and not premised on mobilized soil fertility. Gafsa, merely a city in North Africa, was rejuvenation for phosphorus-starved German soils. Nauru, a little island speck in the Pacific, is a similar nutritional savior to the Japanese. Hitler's move eastward was a hope looking to the Russian fertility reserves. The hoverings of his battleship, Graf Spee, around Montevideo, and his persistence in Argentina were designs on

the last of the world's rich store of less exploited soil fertility in the form of corn, wheat, and beef much more than they were maneuverings political or naval advantage. Some of these historic martial events serve to remind us that "an empty stomach knows no laws" and that man is in no unreal sense, an animal that becomes a social and political being only after he has consumed some of the products of the soil.

DIFFERENCES IN SOIL FERTILITY GIVE US AN EAST AND A WEST AS WELL AS A NORTH AND A SOUTH

In view of our youthfulness as an extensive country, our different geographic areas have registered themselves mainly as differences in body comfort, whether hot or cold, wet or dry. The free flow of foods and food constituents by means of cheap transportation has not allowed recognition of differences in quality as well as in kind of our foods in adjoining districts according to soil differences. We have not yet marked out our country into the smaller patchwork districts with distinctive local colorings as the Old World has in the opinion of visitors from the New World. Limitations in travel, difficulties in food delivery, and all the other restrictions now making us more local, will soon emphasize differences and deficiencies according to the soils by which we live.

Geographic divisions to give us an East and a West, and a North and a South for the eastern half of the country, are commonly interpreted as separations according to differences in modes of livelihood, social customs, or political affiliations. Differences in rainfall and temperature are readily acknowledged. But that these weather the basic rock to make soils so different that they control differences in vegetation, animals, and humans, by control of their nutrition is not so readily granted. That "we are as we eat" and that we eat according to the soil fertility, are truths that will not so generally and readily be accepted. Acceptances are seemingly to come not by deduction but rather through disaster.

PATTERNS OF NOURISHMENT ARE PREMISED ON THE PATTERN OF SOIL FERTILITY

We have been speaking about vegetation by names of crop species and by tonnage yields per acre. We have not considered plants for their chemical composition and nutritive value according to the fertility in the soil producing them. This failure has left us in confusion about crops and has put plant varieties into competition with--rather than in support of--one another. Now that the subject of nutrition is on most every tongue, we are about ready for the report that vegetation as a deliverer of essential food products of its own synthesis is limited by the soil fertility.

Proteinaceousness and high mineral contents, as distinct nutritive values, are more common in crops from soils formed in regions of lower rainfall and of less leaching as for example the "Midlands", or the midwestern part of the United States. "Hard" wheat, so-called because of its high protein content needed for milling the "patent" flour for "light" bread, is commonly ascribed to regions of lower annual rainfalls. "Soft" wheat is similarly ascribed to regions of higher rainfalls. The high calcium content, the other liberal mineral reserves, and the pronounced activities of nitrogen within the less-leached soil, however, are the causes when experimental trials supplying the soil with these fertility items in high rainfall regions can make hard wheat where soft wheat is common.

The proteinaceous vegetation and the synthesis by it of many unknowns which, like proteins, help to remove hidden hungers and encourage fecundity of both man and animal are common in the prairie regions marked by the moderate rainfalls. It is the soil fertility, rather than the low precipitation, that gives the Midwest, or those areas bordering along approximately the 97th meridian these distinctions: (a) its selection by the bison in thundering herds on the "buffalo grass"; (b) the wheat which taken as a whole rather than as refined flour is truly the "staff of life"; (c) animals on range nourishing themselves so well that they reproduce regularly; and (d) the more able-bodied selectees for military service of whom seven out of ten are chosen in contrast to seven rejected out of ten, in one of the southern states where the soils are more exhausted of their fertility.

Protein production, whether by plant, animal, or man, makes demands on the soil-given elements. Body growth among forms of higher life is a matter of soil fertility and not only one of photosynthesis. It calls for more than rainfall, fresh air and sunshine.

The heavier rainfall and forest vegetation of the eastern United States mark off the soils that have been leached of much fertility. Higher temperatures in the southern areas have made more severe the fertility-reducing effects of the rainfall. Consequently, vegetation there is not such an effective synthesizer of proteins. Neither is it a significant provider of calcium, phosphorus, magnesium, or the other soil-given, foetus-building nutrients. Annual production as tonnage per acre is large, particularly in contrast to the sparsity of that on the western prairies. The East's production is highly carbonaceous, however, as the forests, the cotton, and the sugar cane testify. The carbonaceous nature is contributed by air, water, and sunlight more than by the soil. Fuel and fattening values are more prominent than are aids to growth and reproduction.

Here is a basic principle that cannot be disregarded. It has signal value as we face nutritional problems on a national scale. It is, of course, true that soils under higher rainfalls and temperatures still supply some fertility for plant production. Potassium, however, dominates that limited supply to give prominence to photosynthesis of carbonaceous products. The insufficient provision of calcium and of all the other requisite elements usually associated with calcium does not permit the synthesis, by internal performances of plants, of the proteins and many other compounds of equal nutritive value. The national problem is largely one of mobilizing the calcium and other fertility elements for growing protein and not wholly one of redistributing proteins under federal controls. The soil fertility pattern on the map delineates the various areas of particular success or particular trouble in nutrition. It marks out the areas where, by particular soil treatments, the starving plants can be given relief.

THE FERTILITY PATTERN OF EUROPE IS A MIRROR PICTURE OF OUR OWN

The more concentrated populations in the United States are in the East and on the soils of lower fertility. For those people, Horace Greeley spoke with good advice when he said, "Go West young man." It was well that they trokked to the semi-humid midwest where the hard wheat grows on the chernozem soils, and where both the bread basket and the meat basket are well-laden and carried by the same provider, viz; the soil. It was that move that spelled our recent era of prosperity.

In Europe the situation is similar but the direction of travel was reversed and the time period has been longer. It is western Europe that represents the concentrated populations on soils of lower fertility under heavier rainfall. Peoples there reached over into the pioneer United States for soil fertility by trading for it the goods "made in Germany". More recently the hard wheat belt on the Russian chernozem soils has been the fertility goal under the Hitlerian move eastward. Soil fertility is thus a cause of no small import in the world wars.

CALCIUM AND PHOSPHORUS ARE PROMINENT IN THE SOIL FERTILITY PATTERN AS IT DETERMINES THE PATTERN OF NUTRITION OF PLANTS AND ANIMALS

Life behaviors are more closely linked with soils as the basis of nutrition than is commonly recognized. The depletion of soil calcium through leaching and cropping, and the almost universal deficiency of soil phosphorus, connect readily with animals when bones are about the complete body depositories for these two elements. In the forest, the annual drop of leaves and their decay to pass their nutrient elements through the cycle of growth, and decay again, are almost a requisite for tree maintenance. Is it any wonder then that dropped antlers and other skeletal forms are eaten by animals to prohibit their accumulation while their calcium and phosphorus stay in the animal cycle? Deer in their browse will select trees given fertilizers in preference to those untreated. Pine tree seedlings along the highway as transplantings from fertilized nursery soils are taken by deer when the same tree species in the adjoining forests go untouched. Wild animals truly "know their medicines" when they take plants on particular levels of soil fertility.

The distribution of wild animals, the present pattern of distribution of domestic animals, and the concentration of animal diseases, can be visualized as superimpositions on the soil fertility pattern as it furnishes nutrition. We have been prone to believe these patterns of animal behaviors wholly according to climate. We have forgotten that the eastern forest areas gave the Pilgrims limited game among which a few turkeys were sufficient to establish a national tradition of Thanksgiving. It was on the fertile prairies of the Midwest, however, that bison were so numerous that only their pelts were commonly taken.

Distribution of domestic animals today reveals a similar pattern, but more by freedom from "disease"--more properly freedom from malnutrition--and by greater regularity and fecundity in reproduction. It is on the lime-rich, unleached, semi-humid soils that animals reproduce well. It is there that the concentrations of diseases are lower and some diseases are rare. There beef cattle are multiplied and grown to be shipped to the humid soils where they are fattened. Similar cattle shipments from one fertility level to another are common in the Argentine.

In going from midwestern United States eastward to the less fertile soil, we find that animal troubles increase and become a serious handicap to meat and milk production. The condition is no less serious as one goes south or southeastward. The distribution patterns of milk fever, of acetoneuria, and of other reproductive troubles, that so greatly damage the domestic animal industry, suggest themselves as closely connected with the soil fertility pattern that locates the proteinaceous, mineral-rich forages of higher feeding values in the prairie areas but leaves the more carbonaceous and more often deficient feeds for the East and Southeast with their forest areas. Troubles in the milk sheds of eastern and southern cities are more of a challenge for the agronomists and soil scientists than for the veterinarians.

EXPERIMENTAL STUDIES REFLECT CALCIUM AND PHOSPHORUS AS BENEFICIAL SOIL TREATMENTS IN PHYSIOLOGY OF PLANTS AND ANIMALS

Experiments using soil treatments have demonstrated the important roles that calcium and phosphorus can play in the animal physiology and reproduction by way of the forages and grains from treated soils. Applied on adjoining plots of the same area, their effects were registered in sheep as differences in animal growth per unit of feed consumed, and as differences in the quality of the wool. Rabbits also grew more rapidly and more efficiently on hay grown where limestone and superphosphate had been used together than where phosphate alone had been supplied.

The influence of added fertilizers registers itself pronouncedly in the entire physiology of the animal. This fact was indicated not only by differences in the weight and quality of the wool, but in the bones and more pronouncedly in semen production and reproduction in general. Rabbit bones varied widely in breaking strength, density, thickness, hardness and other qualities beside mass and volume. Male rabbits used for artificial insemination became sterile after a few weeks on lespedeza hay grown without soil treatment, while those eating hay from limed soil remained fertile. That the physiology of the animal, seemingly so far removed from the slight change in chemical condition in the soil, registered the soil treatment, is shown by the resulting interchange of the sterility and fertility of the lots with the interchange of the hays during the second feeding period. This factor of animal fertility alone is an economic liability on less fertile soil, but is a great economic asset on the soils that are more fertile either naturally or made so by soil treatments.

ANIMAL INSTINCTS ARE HELPFUL IN MEETING THEIR NUTRITIONAL NEEDS

Instincts for wise choice of food are still retained by the animals in spite of our attempts to convert the dairy cow into a chemical engineering establishment wherein her ration is as simple as urea and phosphoric acid mixed with carbohydrates and proteins, however crude. Milk, which is the universal food with high efficiency because of its role in reproduction, cannot as yet be reduced to the simplicity of chemical engineering when calves become affected with rickets in spite of ample sunshine and plenty of milk, on certain soil types of distinctly low fertility. Rickets, as a malnutrition "disease" according to soil type, need not be a new concept, so far as this trouble affects calves.

Even if we try to push the cow into the lower levels in the biotic pyramid, or even down to that of plants and microbes that alone can live on chemical ions not requisite as compounds, she still clings to her instincts of selecting particular grasses in mixed pasture herbage. Fortunately, in her physiology she strikes up a partnership with the microbes in her paunch where they synthesize some seven essential vitamins for her. We are about to forget, however, that these paunch-dwellers cannot be refused in their demands for soil fertility by which they can meet this expectation. England's allegiance in war time to cows as ruminants that can carry on these symbiotic vitamin synthesis, and her reduction of the population of pigs and poultry that cannot do so, bring the matter of soils more directly into efficient service for national nutrition than we have been prone to believe.

The instincts of animals are compelling us to recognize soil differences. Not only do the dumb beasts select herbage according as they are more carbonaceous or proteinaceous, but they select from the same kind of grain the offerings according to the different fertilizers with which the soil was treated. Animal

troubles engendered by the use of feeds in mixtures only stand out in decided contrast. Hogs select different corn grains from separate feeder compartments with disregard of different hybrids but with particular and consistent choice of soil treatments. Rats have indicated their discrimination by cutting into the bags of corn that were chosen by the hogs and left uncut those bags not taken by the hogs. Surely the animal appetite, that calls the soil fertility so correctly, can be of service in guiding animal production more wisely by means of soil treatments.

Dr. Curt Richter of the Johns Hopkins Hospital has pointed to a physiological basis for such fine distinctions by rats, as an example. Deprived of insulin delivery within their system, they ceased to take sugar. But dosed with insulin they increased consumption of sugar in proportion to the insulin given. Fat was refused in the diet similarly in accordance with the incapacity of body to digest it. Animal instincts are inviting our attention back to the soil just as differences in animal physiology are giving a national pattern of differences in crop production, animal production, and nutritional troubles too easily labeled as "diseases" and thus accepted as inevitable when they ought to have remedy by attention to the soil. The soils determine how well we fill the bread basket and the meat basket.

PATTERNS OF POPULATION DISTRIBUTION ARE RELATED TO THE SOIL

The soil takes on national significance when it prompts the Mayor of the eastern metropolis to visit the "Gateway to the West" to meet the farmers dealing with their production problems. More experience in rationing should make the simple and homely subject of soils and their productive capacity household words amongst urban as well as rural peoples. Patterns of the distribution of human beings and their diseases, that can be evaluated nationally on a statistical basis as readily as crops of wheat or livestock, are not yet seen in terms of the soil fertility that determines one about as much as the other. Man's nomadic nature has made him too cosmopolitan for his physique, health, facial features, and mental attitudes to label him as of the particular soil that nourished him. His collection of foods from far-flung sources also handicaps our ready correlation of his level of nutrition with the fertility of the soil. We have finally come to believe that food processing and refinement are denying us some essentials. We have not yet, however, come to appreciate the role that soil fertility plays in determining the nutritive quality of foods, and thereby our bodies, and our minds. Quantity rather than hidden quality is still the measure.

Now that we are thinking about putting blanket plans as an order over states, countries, and possibly the world as a whole, there is need to consider whether such can blot out the economics, customs and institutions that have established themselves in relation to the particular soil's fertility. Since any civilization rests or is premised on its resources rather than on its institutions, changes in the institution cannot be made in disregard of so basic a resource as the soil.

NATIONAL OPTIMISM AND HOPE ARISE THROUGH WISE ATTENTION TO SOIL FERTILITY

Researchers in soil science, plant physiology, ecology, human nutrition, and other sciences have given but a few years of their efforts to human welfare. These contributions have looked to hastened consumption of material surpluses from unhindered production for limited territorial use. Researches are now to be applied to production, and a production that calls for use of nature's synthesizing forces for food production more than to simple non-food conversions. When our expanded chemical industry is permitted to turn from war-time to peace-time pursuits, it is to be hoped that a national consciousness of declining soil fertility can enlist our sciences and industry into rebuilding and conserving our soils as the surest guarantee of the future health and strength of the nation.